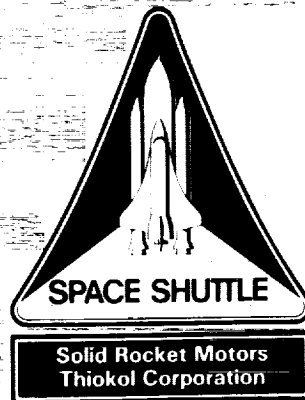


Ray Mitchell  
SA/2

TWR-19899



# Qualification of Improved Joint Heaters Final Test Report

14 September 1989

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Marshall Space Flight Center, Alabama 35812

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Qualification of Improved Joint Heaters  
Final Test Report

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## ABSTRACT

Qualification testing of the Redesigned Solid Rocket Motor improved igniter-to-case joint and field joint heaters was conducted on the fired TEM-04 static test motor and was completed on 7 Sep 1989. The purpose of the test was to certify the installation and performance of the improved joint heaters for use on flight motors. The changes incorporated in the improved heaters improve durability and should reduce handling damage.

The igniter-to-case joint and field joint primary heater circuits were subjected to five 20-hr "ON" cycles. The heater redundant circuits were then subjected to one 20-hr "ON" cycle. Voltage, current, and temperature set point values were maintained within the specified limits for both heaters during each "ON" cycle.

When testing was complete, both heaters were removed and inspected. No discolorations or any other anomalies were found on either of the heaters. Based on the successful completion of this test, it is recommended that the improved igniter-to-case joint and field joint heaters be used on future flight motors.

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## INTRODUCTION

This report documents the procedures, performance, and results obtained from the Improved Field Joint and Igniter-to-Case Joint Heater Qualification Test. The purpose of the test was to certify the installation and performance of the improved joint heaters for use on flight motors. The changes incorporated in the improved heaters are intended to improve durability and reduce the possibility of damage due to handling. The purpose of the heaters is to maintain joint temperatures within the limits defined by Contract End Item Specification CPW1-3600.

The test article assembly began on 23 Aug 1989, testing began on 28 Aug 1989, and disassembly/inspection was completed on 7 Sep 1989. Testing was performed in the Thiokol Static Test Fire Bay T-24, in accordance with CTP-0138, "Qualification Test Plan for the Improved Joint Heaters."

### 1.1 TEST ARTICLE DESCRIPTION

The test article consisted of the improved field joint and igniter-to-case joint heaters installed on the postfired Technical Evaluation Motor - 04 (TEM-04). The improved field joint heater (1U76967) with a complete Field Joint Protection System (FJPS) was installed on the forward field joint, and the improved igniter-to-case joint heater (1U76969) was installed on the igniter adapter (Figures 1 through 3). Assembly and components of the test article, other than the use of improved heaters, were flight configuration. Previously refurbished heater power cables were used during this test.

The improved heaters consist of chemically etched, primary and redundant foil circuits which are superimposed upon one another, enclosed within a wire mesh grounding shield, and laminated in Kapton<sup>®</sup> and FEP Teflon insulation. Configuration of the heater circuits was not changed in the design of the improved heaters.

The following changes have been incorporated in the improved heaters:

- a. Adding shrink sleeving over the full length of individual conductors within the heater connector Radio Frequency Interference (RFI) backshells. This sleeving provides additional electrical insulation within the backshell.
- b. Reducing the number of field joint heater conductors from four to two. The two additional conductors did not carry current and were not needed. This change also increases the amount

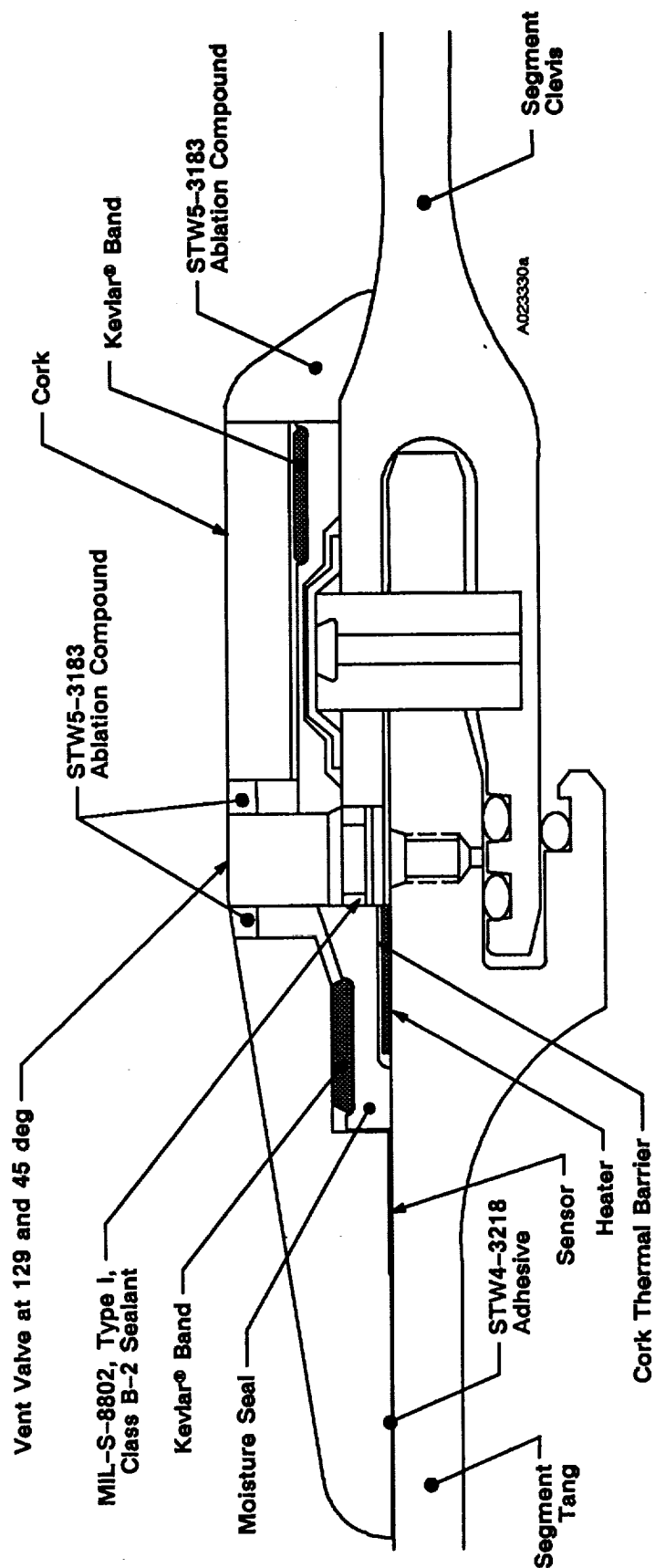
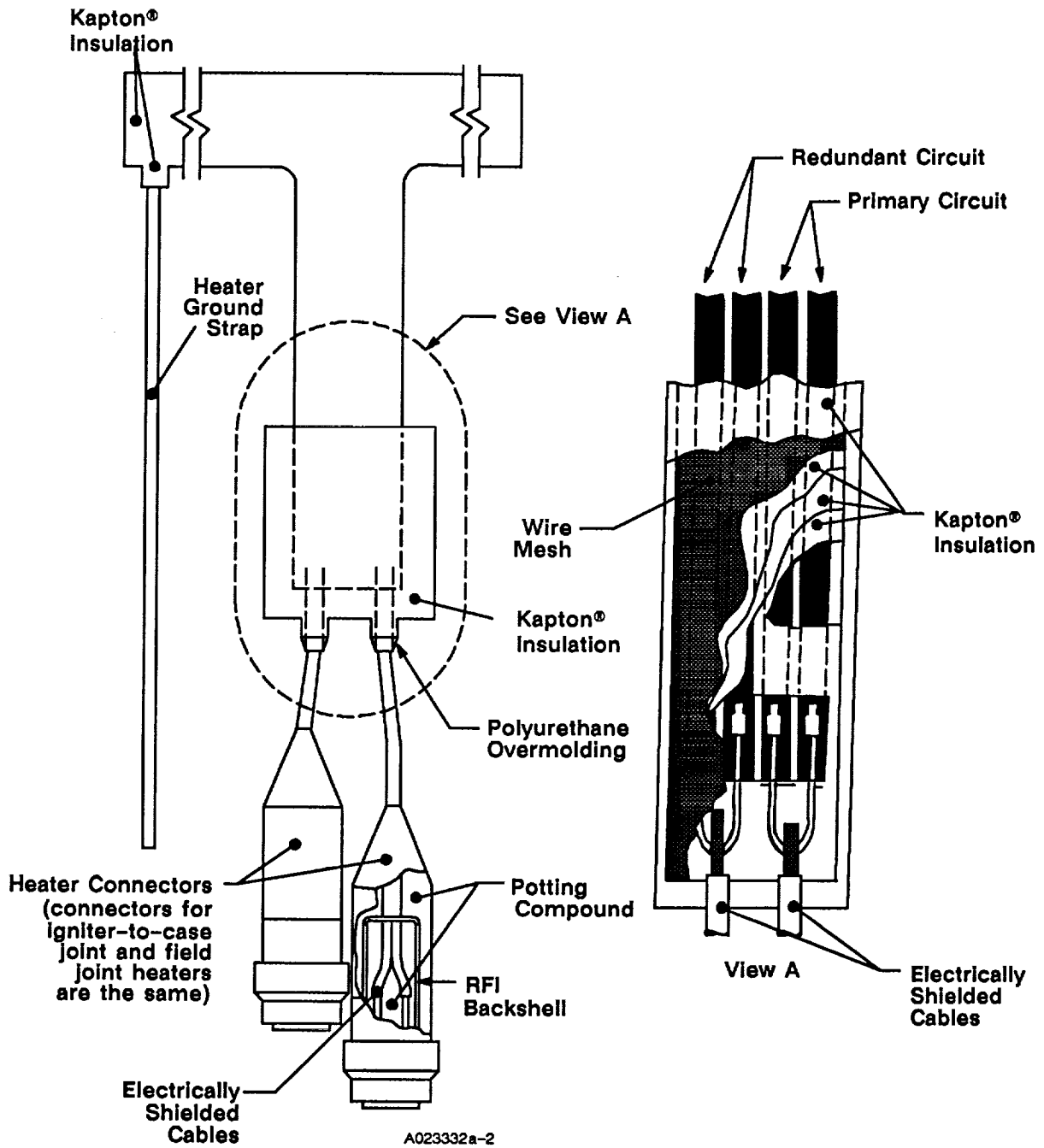


Figure 1. Field Joint Protection System



**Figure 2. Improved Field Joint Heater Assembly**



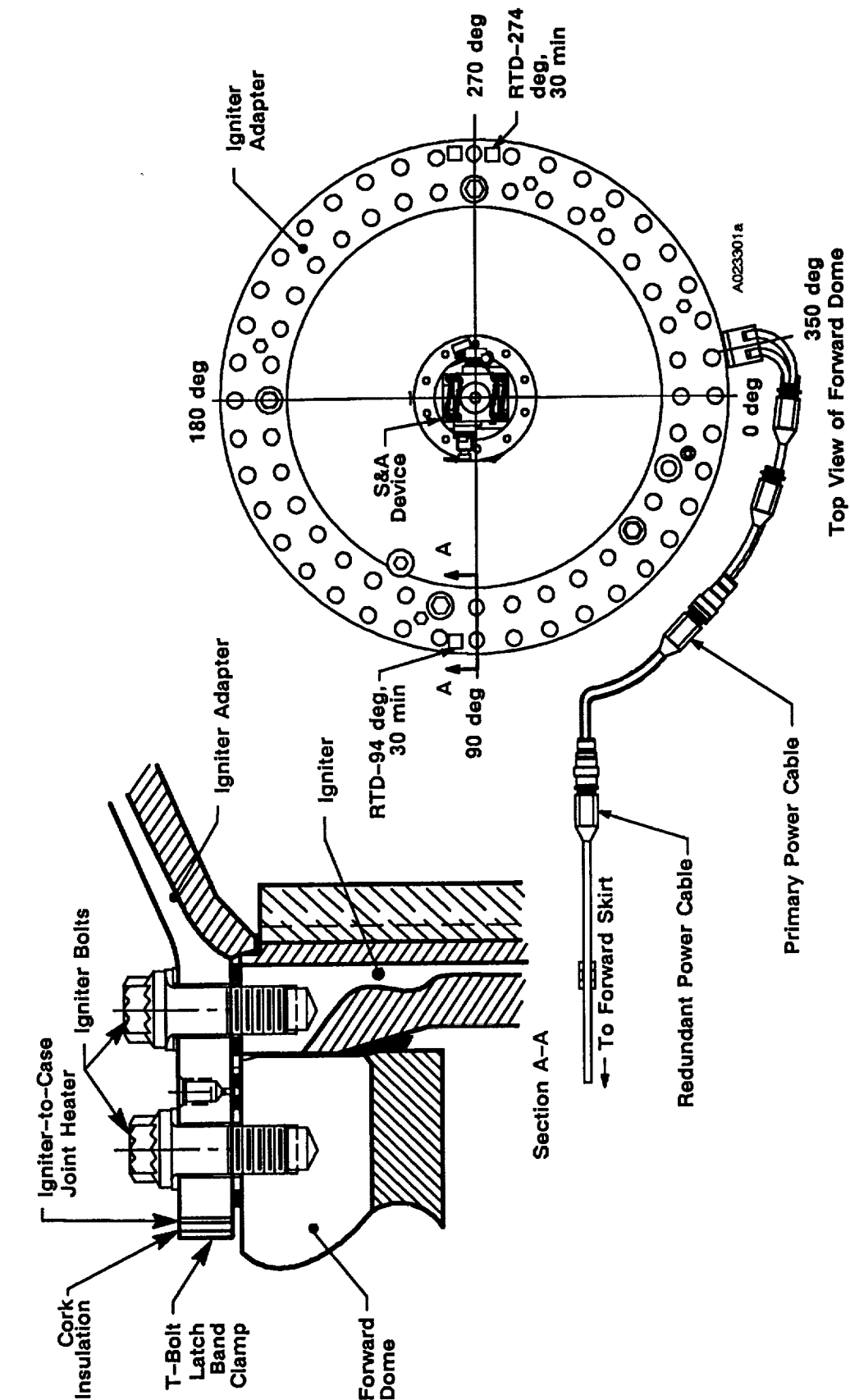


Figure 3. Igniter-to-Case Heater Location

- of potting compound within the connector backshell, and thus gives a wider separation between individual conductors and between the conductors and the backshell to prevent shorting.
- c. Increasing the size of the connector backshells to allow additional separation between individual conductors and between the conductors and the backshell to prevent shorting.
  - d. Specifying the angular location of the connector master key on the field joint heater. Without this specification, the heater connector and power cable may be improperly positioned and subjected to more twisting than necessary for coupling to occur. Twisting stresses the cable and could cause a heater or cable malfunction.
  - e. Incorporating a more flexible potting compound in and around the connector backshells. If it is necessary to twist the connectors, less stress will be induced on the conductors with this improvement.
  - f. Adding polychloroprene (neoprene) shrink sleeving to the heater power leads. This sleeve should reduce handling damage to the heater power leads.
  - g. Adding polyurethane overmolding to the connector backshell and heater lead egress on both heater assemblies to improve moisture resistance and add strain relief for the leads.
  - h. Incorporating an additional layer of Kapton<sup>®</sup> in the lead egress area of the igniter heater, to provide additional electrical insulation.
  - i. Changing the insulation of individual conductors from Kapton<sup>®</sup> to Teflon. Teflon is less stiff and less subject to damage by notching.
  - j. Providing an additional layer of Kapton<sup>®</sup> to both sides of each ground strap egress on the field joint heater, to prevent ground strap damage at the egress during normal handling.

## OBJECTIVE

The objectives of Test Plan CTP-0138 were to:

- a. Demonstrate fit and durability of the new igniter-to-case joint heater and new field joint heater with field joint protection system.
- b. Certify the 1U76967 field joint heater for use on redesigned solid rocket motor (RSRM).
- c. Certify the 1U76969 igniter heater for use on RSRM.
- d. Demonstrate cycle operation of the heaters for five countdown periods (100-hr minimum).

## EXECUTIVE SUMMARY

### 3.1 SUMMARY

This section contains an executive summary of the key results from test data evaluation and post-test inspection. Additional information and details can be found in Section 6 (Results and Discussion).

The igniter-to-case joint and field joint primary heater circuits were subjected to five 20-hr "ON" cycles. The heater redundant circuits were then subjected to one 20-hr "ON" cycle. Voltage, current, and temperature set point values were maintained within the specified limits for both heaters during each "ON" cycle. Continuity, insulation resistance, and dielectric withstanding voltage electrical tests were performed after each "ON" cycle and each check passed successfully. All testing followed the procedures and all values fell within the limits defined in Test Plan CTP-0138.

Following the completion of the final electrical checks, the igniter-to-case joint and field joint heaters were removed from the case. The igniter heater was immediately inspected and no discolorations or any other anomalies were found. The field joint heater required cleaning prior to inspection, to remove the black heat transfer cement. After cleaning, the field joint heater was also carefully inspected and no discolorations or any other anomalies were found. Both heaters were in excellent condition.

### 3.2 CONCLUSIONS

The following listing is the conclusions as they relate specifically to the objectives. Additional information about the conclusions can be found in Section 6 (Results and Discussion).

| <u>Objective</u>   | <u>Conclusions</u>   |
|--|--|
| a. Demonstrate fit and durability of the new igniter-to-case joint heater and new field joint heater with field joint protection system. | Demonstrated. The improved igniter-to-case joint and field joint heaters fit properly when installed per the installation requirements of Drawing 7U77080. |
| b. Certify the 1U76967 field joint heater for use on RSRM.   | Certified. The primary heater circuit of the improved field joint heater withstood five 20-hr "ON" cycles with no degradation or failure.                  |

- c. Certify the 1U76969 igniter heater for use on RSRM.

Certified. The primary heater circuit of the improved igniter-to-case joint heater withstood five 20-hr "ON" cycles with no degradation or failure.

- d. Demonstrate cycle operation of the heaters for five countdown periods (100-hr min).

Demonstrated. The primary heater circuits of the improved igniter-to-case joint and field joint heaters withstood five 20-hr "ON" cycles with no degradation or failure. The redundant heater circuits of each improved heater also withstood an additional 20-hr "ON" cycle with no degradation or failure.

### 3.3 RECOMMENDATIONS

Based on the successful completion of all test objectives, with electrical testing performed after each heater "ON" cycle and no anomalies noted during or after each heater "ON" cycle, it is recommended that the improved igniter-to-case joint and field joint heaters be used on future flight motors.

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**INSTRUMENTATION**

All test instruments were electrically zeroed and operationally verified per MIL-STD-45662. The following instruments were used:

| <u>Instrument</u>      | <u>Make</u> | <u>Model No.</u> | <u>Serial/Lot No.</u> |
|------------------------|-------------|------------------|-----------------------|
| Digital Volt<br>Meter  | Fluke       | 8060A            | SL32556               |
| Megometer              | Hipotronics | HM6B             | SL32300               |
| High Voltage<br>Tester | Slaughter   | 103/105<br>AC/DC | SL34262               |

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**PHOTOGRAPHY**

After disassembly and clean-up, still color photographs of each heater were taken. Copies of the photographs taken (series 112679) are available from the Thiokol Photographic Services Department.

## RESULTS AND DISCUSSION

### 6.1 TEST ARTICLE ASSEMBLY

Continuity and Insulation Resistance (IR) electrical tests were successfully performed on both heaters prior to installation.

An improved igniter-to-case joint heater (1U76969) was installed per flight configuration on the igniter adapter of the fired TEM-04 static test motor. Continuity, IR, Dielectric Withstanding Voltage (DWV), and heater functional tests were successfully performed on the igniter-to-case joint heater after installation.

An improved field joint heater (1U76967) with a flight configuration FJPS was then installed on the forward field joint of the static test motor. Continuity, IR, DWV, and heater functional tests were successfully performed on the field joint heater after the moisture seal installation. Continuity, IR, and DWV tests were successfully repeated after the extruded cork installation.

All electrical testing followed the procedures defined in Test Plan CTP-0138. All electrical testing values (also performed after each heater "ON" cycle, except for the heater functional test) fell within the limits defined below:

- Continuity Test. DC resistance of the primary and redundant heater elements, measured at the connector pins, was between:
  - (1) 95.25 and 105.32 ohms for the igniter-to-case heater
  - (2) 11.20 and 12.40 ohms for the field joint heater
- Insulation Resistance Test. Insulation resistance was at least 100 megohms for an applied voltage of  $500 \pm 50$  Vdc. Voltage was applied between:
  - (1) Primary and redundant heater elements
  - (2) Each conductor and connector shell
- Dielectric Withstanding Voltage Test. The heaters withstood the application of  $1,500 \pm 75$  Vdc for one minute maximum without exceeding leakage current of 1 milliamp. Voltage was applied between:
  - (1) Primary and redundant heater elements
  - (2) Each conductor and connector shell

- Heater Functional Test. Power was applied to the heaters for:
  - (1) One hour on the primary and redundant heater elements of the improved igniter-to-case joint heater
  - (2) Fifteen minutes on the primary and redundant heater elements of the improved field joint heater

## 6.2 TEST

The igniter-to-case joint and field joint primary heater circuits were subjected to five 20-hr "ON" cycles. The heater redundant circuits were then subjected to one 20-hr "ON" cycle. Voltage, current, and temperature set point values were maintained within the specified limits for both heaters during each "ON" cycle. Continuity, IR, and DWV electrical tests were performed after each "ON" cycle and each check passed successfully. All testing followed the procedures and all values fell within the limits defined in Test Plan CTP-0138.

## 6.3 DISASSEMBLY AND RESULTS

Following the completion of the final electrical checks, the igniter-to-case joint and field joint heaters were removed from the case.

For the igniter-to-case joint heater disassembly, the T-bolt latch band clamp was first loosened and then removed. The cork insulation and igniter-to-case joint heater were then removed from the igniter adapter. The igniter heater was immediately inspected and no discolorations or any other anomalies were found.

For the field joint heater disassembly, a section of extruded cork was first cut away to provide access to the Kevlar® straps and moisture seal. Both Kevlar® straps were then cut and an axial cut was made through the moisture seal. The moisture seal (and cork) was then stripped circumferentially from the motor. This exposed the heater for inspection and removal. The heater was inspected prior to removal and no anomalies were observed. The heater was then carefully removed and cleaned to remove the residual heat transfer cement. After cleaning, the field joint heater was inspected and no discolorations or any other anomalies were found (Figure 4).



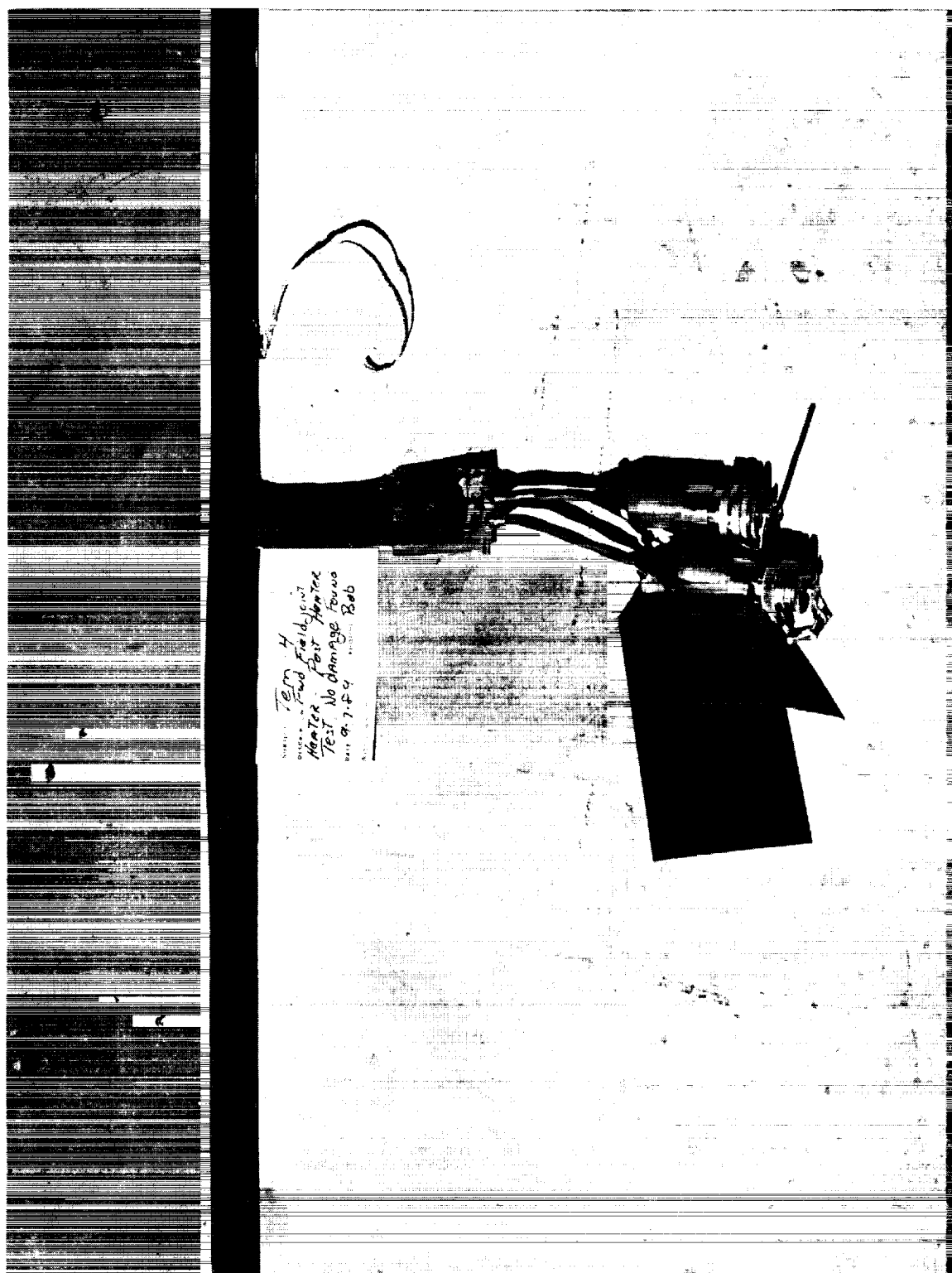


Figure 4. Field Joint Heater (Post-Test)

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**APPLICABLE DOCUMENTS**

| <u>Document No.</u>       | <u>Title</u>  |
|---------------------------|---|
| CPW1-3600                 | Prime Equipment Contract End Item (CEI) Detail Specifications |
| CTP-0138                  | Qualification Test Plan for the Improved Joint Heaters        |
| <u>Military Standards</u> | <u>Title</u>  |
| MIL-STD-45662             | Calibration System Requirements                               |
| <u>Drawing No.</u>        | <u>Title</u>  |
| 1U76967                   | Heater - Field Joint  |
| 1U76969                   | Heater - Igniter-to-Case Joint                                |
| 7U77080                   | Joint Protection System, Post-Test, TEM-4                     |

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